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14. ABSTRACT: This project developed techniques to detect small defects in NbTi magnet wire at room-temperature using a flow-through high-transition temperature (T_c) superconducting quantum interference device (SQUID) system. The ability to detect small defects in km-long sections of NbTi magnet wire could improve the production yield of high-field magnets for power and medical applications. Such magnets are wound from continuous sections of wire up to 1 km long, and a single small defect in the wire can limit the field the magnet produces, making it unsuitable. It is highly desirable to be able to locate defects in wire using non-destructive evaluation (NDE) of the wire before the magnet is wound. Ideally, the NDE system must be able to detect small buried defects due to yields (wire stretched beyond elastic limit) and occlusions (non-conducting impurity grain introduced into the wire). Such defects have proven to be difficult to find using visual inspection or conventional eddy current detection, and better techniques are needed.

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Final Performance Report for
Development of a Flow-Through SQUID System
for
Non-Destructive Evaluation of MRI Wire

AFOSR Award Number FA95500510028

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The objective of this project was to develop techniques to detect small defects in km-long sections of NbTi magnet wire at room-temperature using a flow-through high-transition temperature (T_c) superconducting quantum interference device (SQUID) system. The ability to detect small defects in km-long sections of NbTi magnet wire could improve the production yield of high-field magnets for Medical Resonance Imaging (MRI) and power applications. Such magnets are wound from continuous sections of wire up to 1 km long, and a single small defect in the wire can limit the field the magnet produces, making it unsuitable. Ideally, the NDE system must be able to detect small buried defects due to yields (wire stretched beyond elastic limit) and occlusions (non-conducting impurity grain introduced into the wire). Such defects have proven to be difficult to find using visual inspection or conventional eddy current detection, and better technique are needed.

During the two years of this project, the main tasks we accomplished were:

- (1) Built a stepper motor controlled wire feed system and tested it on a cryo-cooled flow-through high- T_c SQUID system;
- (2) Used the system to measure ac magnetic signals from intentional defects (small through holes) in 6 ft long 2 mm diameter brass rod driven at up to 20 cm/s;
- (3) Developed a simple automatic detection scheme using high pass filter and threshold detection to reliably detect through holes down to 300 μm diameter;
- (4) Rebuilt SQUID tip and electronics for higher bandwidth (about 20 kHz) and tested the complete system;
- (5) Developed a simple model of the defect signal, compared observed signals to the model, and developed estimates for minimum defect size observable with a given level of injection current;
- (5) Considered two designs for alternative detection schemes. The aim of the first scheme was to improve the detection of smaller holes by using a coaxial return current path that would produce a field that would cancel the background field from the average current through the wire under test. The aim of the second techniques was to remove the need for making connections to the wire by using a pair of anti-Helmholtz coils to produce a large field gradient that the wire would then be swept through.